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Results from the ROSAT Deep Galactic Survey

The ROSAT data base of public archival pointings is a large resource for the study of soft X-ray sources. We set out to find sources with unusual high X-ray to optical flux ratio in the ROSAT archive. Our initial effort brought new insight into three different group of objects: millisecond pulsars, old isolated neutron stars and active galactic nuclei.

Millisecond pulsars: We derived upper limits to five known radio pulsars and found evidence for the new detection of PSR B1821-24. We compared our results with predicted X-ray luminosities by Seward and Wang (1988) and Ögelman (1994).
The X-ray luminosities of PSRs B1257+12 and J0437–4715, millisecond pulsars with similar periods and spin-down rates, are found to differ by more than a factor of 25. X-ray emission from radio pulsars has been ascribed to a thermal component arising from a surface hot-spot and a power law magnetospheric component (Halpern & Ruderman 1993). In the context of this model and these observations, we argue that the orientation of the magnetic and rotation axes with respect to the line of sight is very different for PSR J0437–4715 compared to PSR B1257+12. Finally, we suggest that the beaming factor for X-ray emission is independent of the pulsar period, unlike that for radio emission; if so, most millisecond pulsars are visible in the radio but not at X-ray energies [Danner et al., ApJ 436, L153].
We followed up our possible detection of pulsed emission from PSR B1821-24 with a much deeper ROSAT HRI observation. The new data confirms our initial finding. PSR B1821-24 is found to be pulsed at the radio period and shows very narrow peak profiles. This further supports our interpretation that the emission is indeed narrowly beamed and probably magnetospheric in nature [to be submitted to Nature].

Old Isolated Neutron Star: Our interest in old neutron stars that are not active as radio pulsars has been the main force behind the thesis project of R. Danner. The preliminary results from the analysis of public ROSAT data spurred a systematic search of the ROSAT All-Sky Survey. A survey of X-ray sources in molecular clouds at high galactic latitudes demonstrated that we find 100 to 1000 times fewer neutron stars than estimated from theory. We also conducted a survey of X-ray sources in galactic dark cloud and did not find any bright source with desirable properties, large f_X and with no optical counterpart (e.g. the Walter et al. source, Nature, 379, 233, 1996). The brevity of this section does not reflect the immense amount of work that has gone into this project. A possible interpretation of our null result is that the mean velocity of old neutron stars is higher than the mean velocity of radio pulsars.

Active Galactic Nuclei: AGNs were long thought to be easily distinguishable from potential accreting objects because of their hard spectrum. Searches for soft X-ray sources, spurred on by considerations discussed above, have shown the existence of a whole new class of AGNs with soft X-ray spectra. This project was carried out in collaboration with colleagues at the Max-Planck Institute for Extraterrestrial Physics. We reported on the follow-up optical and radio observations which allow the identification of three of these objects as Narrow Line Seyfert 1 galaxies, and the fourth as BL Lac object. We have measured small-FWHM Hβ lines, strong FeII emission and weak [OIII] emission in the three Narrow Line Seyfert 1galaxies, in line with known correlations with respect to the steepness of the X-ray spectra.
We have discovered strong optical variability in the BL Lac object and two of the Seyfert galaxies using photographic plates of the Sonneberg Observatory field patrol. We finally discuss the statistical implications of our search algorithm on the expected number density of soft X-ray selected AGN and conclude that up to 30% of X-ray selected AGN might have supersoft X-ray spectra [to be published in A&A, Greiner et al.]. We find that warm absorber models can satisfactorily explain the observed X-ray spectrum.

Publications

R. Danner, S. R. Kulkarni, S. E. Thorsett, ApJ, 436, L153 (1994)
J. Greiner, R. Danner, et al., A&A (in press)
R. Danner, S. R. Kulkarni et al., Nature (to be submitted)